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UNIVERSITY OF ALBERTA

**THE EFFECTS OF SENSORINEURAL HEARING LOSS
ON SENTENCE REPETITION
IN HEALTHY ELDERLY ADULTS**

BY

JACQUELINE EALES-FORWARD

A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND
RESEARCH IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF MASTER OF SCIENCE
IN SPEECH-LANGUAGE PATHOLOGY

DEPARTMENT OF SPEECH PATHOLOGY AND AUDIOLOGY

EDMONTON, ALBERTA
FALL 1990



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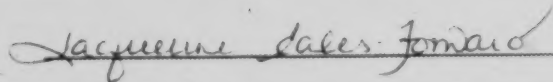
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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled THE EFFECTS OF SENSORINEURAL HEARING LOSS ON SENTENCE REPETITION IN HEALTHY ELDERLY ADULTS submitted by Jacqueline Eales-Forward in partial fulfilment of the requirements for the degree of Master of Science, Department of Speech Pathology and Audiology.

2011-12-13
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*To my grandparents,
Magnhild Eales, Hilda and Robert Randall,
and Helen and Ervin Webster
whose lives exemplify successful aging!*

Abstract

This study investigated the effects of sensorineural hearing loss on the performance of 33 healthy elderly adults with negative histories of neurological disease on the Phrase and Sentence Repetition subtest from the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass & Kaplan, 1983). The average of pure tone thresholds measured at 1000, 2000 and 4000 Hz formed the basis for grouping subjects according to level of hearing acuity. Comparisons were made among older adults with normal hearing, mild hearing impairments and moderate hearing impairments on their ability to repeat high and low probability phrases and sentences from the BDAE. These two types of sentences differ in frequency of usage of constituent words and predictability of verbal content. Speech discrimination scores were used as a covariate. Analysis of covariance indicated a significant difference among the three groups based on hearing level and between types of sentence probability. The interaction between level of hearing acuity and sentence probability approached significance. Results were discussed with reference to the ability of this subtest to discriminate between responses characteristic of aphasia or dementia from those associated with high frequency hearing loss in the absence of aphasia or dementia.

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List of Symbols

The following are a list of phonetic symbols used in the text of this document:

<u>Phonetic Symbol</u>	<u>Example</u>
/a/	law
/u/	you
/i/	me
/s/	sigh
/f/	feel
/ʃ/	shoe
/θ/	thought
/tʃ/	church
/dʒ/	judge

Chapter I. The Problem

Measurement of performance on sentence repetition tasks presented through the auditory modality is essential in the differential diagnosis of aphasia (Goodglass & Kaplan, 1983; Kertesz & Poole, 1982; Schuell, 1973) and cortical dementias (Bayles & Kaszniak, 1987; Obler & Albert, 1981). The diagnostic significance of sentence repetition depends on the pattern of responding on the repetition task and its relation to performances on other subtests. Misdiagnoses may lead to mismanagement of the elderly client (Blair, 1990). Clinical concern has been raised recently regarding the discriminatory function of current aphasia tests (Chapman, 1988) and more specifically the use of sentence repetition tasks with elderly hearing impaired aphasic patients (Norman, 1988, October). The effects of sensorineural hearing loss on speech discrimination tasks employing consonant-vowel syllables and word stimuli have been investigated previously (Corso, 1971; Elliott, Busse & Bailet, 1985; Feldman & Reger, 1967; Gang, 1976; Gelfand, Piper & Silman, 1986; Givens & Jacobs-Condit, 1981; Grady et al., 1984; Jerger, 1973; Preminger & Wiley, 1985), but there have been no investigations to date of the effects of hearing loss on subtests of aphasia diagnostic batteries currently in use.

This study investigated the effects of high frequency sensorineural hearing impairment on healthy ambulatory senior citizens' abilities to repeat phrases and sentences (in the title and hereinafter referred to as sentences) of high- and low-probability from the Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1983). These two types of sentences differ in the frequency of usage of the constituent words and the predictability of the verbal content. Of particular interest was the higher number of high frequency peak-energy

phonemes present in the low probability stimuli and the potential differential effects of this on performance.

Chapter II. Review of the Literature

Research relevant to the scope of this proposed study will be summarized under the headings: Auditory Acuity, Speech Perception, the Boston Diagnostic Aphasia Examination and Pilot Study. Changes in auditory acuity often associated with aging and the implications of such a hearing loss will be reviewed first. It is important for the reader to understand the complexity of the auditory system and the potential effects of declines in this system on older adults' performances on communication assessment tools, specifically on the Sentence Repetition subtest from the Boston Diagnostic Aphasia Examination (Goodglass & Kaplan, 1983).

Auditory Acuity

It is important to distinguish among the various definitions of auditory acuity, hearing impairment and hearing handicap. Auditory acuity refers to the sensitivity of the hearing mechanism to perceive sound. Any decrement in the intensity of a perceived sound because of an organic hearing problem, such as presbycusis, results in a hearing loss or hearing impairment. However, not all hearing impairments cause hearing handicaps. Hearing handicap refers to the effect of the hearing impairment on the affected individual's everyday living. The following discussion will relate the types of presbycusis, the audiometric configuration of presbycusis and the incidence and functional implications of hearing loss in the elderly.

Types of presbycusis

The work of Schuknecht (1964, 1974), based on histopathologic findings in temporal bones, is likely one of the most well known and respected in the

area of pathology of the ear. Schuknecht (1974) states that "the auditory system, like all systems of the body, exhibits senescent changes with the passage of time" (p. 388). The term "presbycusis" was used to refer to "hearing loss caused by the degenerative changes of aging" (Schuknecht, 1974, p. 389). The time of onset and rate of progression may vary widely among individuals. Schuknecht (1964, 1974) attempted to classify presbycusis into four distinct types based on underlying histopathologic changes: (1) Sensory presbycusis, (2) Neural presbycusis, (3) Strial presbycusis, and (4) Cochlear conductive presbycusis.

Sensory presbycusis. Sensory presbycusis is characterized by the degeneration of the organ of Corti, primarily in the basal end of the cochlea where high frequency sounds (above 2000 Hz) are detected. The organ of Corti is a spiral structure located within the cochlea which contains hair cells and supporting cells essential for sound reception. There may also be a concomitant loss of cochlear neurons in the spiral ganglion, which is composed of cell bodies of the first neurons in the auditory pathway. Because of the slow progression of this hearing loss, the frequencies important to speech perception (500 - 2000 Hz) may not be affected. This atrophy is thought to be a consequence of injury to the afferent nerve endings and is termed "secondary neural degeneration", that is, secondary to atrophy of the supporting cells of the organ of Corti (Schuknecht, 1974, p. 390).

Neural presbycusis. Neural presbycusis is the result of a loss of neurons in the spiral ganglion below the critical number "required for effective transmission, integration, and decoding of the patterns of neural flow" (Schuknecht, 1974, p. 391). It affects all segments of the cochlea, but

consistently these effects are more severe in the basal turn (important to high frequency sound reception). Additional neuronal loss in the higher auditory pathways is probable. The hearing impairment is characterized by a loss of speech discrimination ability which is relatively more severe than would be predicted from pure tone hearing thresholds. The audiogram generally has a gradual slope reflecting greater hearing loss in the high frequencies.

Strial presbycusis. Strial presbycusis is characterized as patchy areas of degenerative changes in the stria vascularis, the source of nutritive supply to the organ of Corti, in the middle and apical turns of the cochlea. The apical region of the cochlea is important for the analysis of the speech frequencies (500 - 2000 Hz). There is either partial or complete loss of strial cells. Hearing loss is progressive, characterized by a flat audiometric configuration for pure tone thresholds. Speech discrimination score is typically excellent until the threshold elevation exceeds 50 dB.

Cochlear conductive presbycusis. Cochlear conductive presbycusis is the fourth and final type of presbycusis identified by Schuknecht (1964, 1974). It has not yet been proven pathologically, rather it was devised to explain a documented hearing loss in old age not accounted for by the lack of morphological changes noted in the inner ear. It is posited that the hearing loss is due to a dysfunction of the motion mechanics of the cochlear duct. The hearing loss is characterized by a descending, symmetrical audiometric pattern for pure tone thresholds. Speech discrimination scores are inversely related to the slope of the pure tone threshold gradient. The greatest threshold loss is for the high frequencies which are represented in the basal end of the cochlea.

The diagnosis of presbycusis frequently does not fall into one of the four pure types described. In contrast, there is usually more than one type of degenerative process present (Health & Welfare Canada, 1988). Katsarkas and Ayukawa (1986) found in a retrospective study of 1181 patients over 50 years of age that only 50% of audiograms reviewed could be matched to the histopathologic types described by Schuknecht (1964, 1974). Sensory, neural and cochlear conductive presbycusis were most pertinent to this study since all of these disorders affect high frequency hearing acuity. A description of the consensus of audiometric findings associated with growing older follows.

Audiometric configuration of hearing acuity in elderly adults

There may be controversy as to whether the pathologic findings of presbycusis can be predicted from audiograms, but a review of existing research revealed one consistent finding reached by numerous investigators: there was a strong correlation between age and changes in peripheral hearing acuity, particularly for the higher frequencies (Feldman & Reger, 1967; Grady et al., 1984; Harford & Dodds, 1982; Jerger, 1973; Katsarkas & Ayukawa, 1986; Kryter, 1983; Lebo & Reddell, 1972; Patterson, Nimmo-Smith, Weber, & Milroy, 1982; Robinson & Sutton, 1978; Schow & Nerbonne, 1980; Spoor, 1967). Patterson et al. (1982) found a positive correlation of .70 between age and pure tone hearing threshold levels averaged across frequencies. Correlations increased with increases in individual frequencies. In concordance, Grady et al. (1984) found significantly more hearing loss per decade of subjects' ages at the higher frequencies by comparing the slope of regression lines at 250 and 8000 Hz. The increase in threshold was 3 dB per decade at 250 Hz in comparison with an increase of 13 dB per decade at 8000

Hz. Similarly, Harford and Dodds (1982) reported that hearing sensitivity decreased about 1.5 dB per year between 70 and 80 years of age in ambulatory adults, with the most change noted between 75 to 80 years.

The configuration of the audiogram reflects these correlations between age and hearing acuity. Robinson and Sutton (1978) found two uniform features in their comparative analysis of data taken from eight studies reported in the literature on hearing loss in aged individuals. These features were (1) an accelerating trend of threshold elevation with age and (2) stable threshold levels up to 1000 Hz and an accelerating increase towards higher frequencies. With time, the loss in the high frequencies gradually spreads to the lower frequencies thus affecting the entire speech spectrum. Harford and Dodds (1982) concluded that the audiometric configuration of the older adult was "a gradual high-frequency roll-off averaging 5 dB per octave through the speech range with a decrease of 10 and 15 dB at 4 and 8 kHz respectively" (Harford & Dodds, 1982, p. 109).

Incidence and functional implications of hearing loss

The well-documented decline in auditory acuity associated with the aging process has considerable functional implications for affected elderly people. Acquired hearing impairment was listed as one of the most common chronic health problems of aged individuals, second only to arthritis (Calvani, 1985). Those individuals who have a significant hearing impairment include approximately 20% of those over 65 years, 40% of those over 75 years, and at least 80% of nursing home residents (Bingea, Raffin, Aune, Baye, & Shea, 1982; Harford & Dodds, 1982; Health & Welfare Canada, 1988; Schow & Nerbonne, 1980). Since the number of individuals over 65 years of age is

increasing (Statistics Canada, 1987), the prevalence of hearing loss can be expected to increase proportionally.

This loss of hearing sensitivity likely impacts all aspects of affected individual's daily living, including communication (Rosenhall, Pedersen & Moller, 1987). Hearing impairment has been significantly correlated with emotional, social and communication dysfunction (Mulrow et al., 1990). The psychological manifestations of hearing impairment may include social embarrassment, lowered self esteem, mistrust of social contacts, insecurity, isolation and depression. These consequences may be particularly grave in the older population since communicating with others may be one of the behaviors that is most essential to life satisfaction and self-esteem (Jacobs-Condit, 1984).

In summary, Schuknecht (1964, 1974) described four distinct types of presbycusis based on underlying histopathologic changes associated with the aging process. Despite controversy over the predictability of type of presbycusis based on individuals' audiograms there was a well-documented decline in high frequency hearing acuity with age (Feldman & Reger, 1967; Grady et al., 1984; Harford & Dodds, 1982; Jerger, 1973; Katsarkas & Ayukawa, 1986; Kryter, 1983; Lebo & Reddell, 1972; Patterson, Nimmo-Smith, Weber, & Milroy, 1982; Robinson & Sutton, 1978; Schow & Nerbonne, 1980; Spoor, 1967). This loss of auditory sensitivity affected the social, emotional and communicative welfare of a significant number of elders (Health & Welfare Canada, 1988; Mulrow et al., 1990; Rosenhall et al., 1987). As the proportion of elderly adults within the population increases (Statistics Canada, 1987), the number of hearing impaired individuals can be expected to increase commensurately. If hearing loss affects seniors' activities of daily living, it is probable that reduced hearing sensitivity, in the

absence of aphasia, would also affect their performance on subtests from aphasia batteries requiring acute listening skills. The consequences of reduced hearing on these tasks has yet to be demonstrated.

Speech Perception

Speech perception is the process of understanding the auditory signal (i.e., speech) (Skinner & Shelton, 1985). It refers to the clarity of the sound rather than the intensity of the signal. Many elderly people frequently complain that they can hear, but they cannot understand (Alpiner, 1982). As Nash and Wepman (1973) stated, "the end organ may be normal, yet the older person often shows incomplete auditory comprehension" (p. 243). Adequate speech perception abilities in elders are dependent upon a number of interacting variables. These factors include peripheral hearing acuity (as previously discussed), speech discrimination skills, environmental conditions and the physical properties of sound.

Speech discrimination abilities of seniors

A number of researchers have investigated the speech perception abilities of aged listeners (Bergman, 1980; Corso, 1971; Elliott et al., 1985; Feldman & Reger, 1967; Gang, 1976; Gelfand et al., 1986; Givens & Jacobs-Condit, 1981; Jerger, 1973; Preminger & Wiley, 1985). Feldman and Reger (1967) found that after age 50 there was a systematic decline (approximately 5% per decade) in speech discrimination scores on the C.I.D W-22 phonetically balanced word list (Hirsh et al., 1952). By age 80 this impairment reached a 25% loss in speech discrimination abilities. These researchers felt that this discrimination difficulty was caused by both peripheral and central auditory

factors (Feldman & Reger, 1967). Similarly, Jerger (1973) found a systematic decrement in speech intelligibility performance with increasing age.

Parallel results were found in a more recent study. Givens and Jacobs-Condit (1981) found a significant difference between the consonant identification abilities of those with bilateral sloping sensorineural hearing losses and normal hearing controls. Using consonant-vowel-consonant (CVC) words, they found that the hearing impaired group was able to identify 50% of the consonants compared with the control group which identified 97% under quiet conditions.

Grady et al. (1984) attempted to distinguish the effects of peripheral hearing loss from age-related changes in the central auditory processing of speech stimuli in a cross sectional study of adult males spanning six decades. These researchers found that speech discrimination scores on the Northwestern University #6 word lists (Tillman, Carhart & Wilver, 1966) were negatively correlated with age. This result did not consider the variability in scores that were related to peripheral hearing loss. When partial correlations were computed to remove the influence of peripheral auditory acuity there was no longer a significant correlation between age and speech discrimination score. The authors concluded that "aging in healthy subjects is not necessarily accompanied by a decline in speech perception other than that due to peripheral hearing loss" (p. 107). Correlative evidence was provided by Katsarkas and Ayukawa (1986). These researchers found that the speech discrimination abilities in 86% of their subjects over the age of 50 years (N=1181) was either excellent (>90%) or good (80-89%) in quiet when measured 50 dB above individuals' speech reception thresholds.

Disagreements regarding the effects of aging on speech discrimination abilities may be accounted for partly by the type of stimuli employed in these

studies. Marston and Goetzinger (1972) posited that the deterioration in speech discrimination which accompanies aging may be too subtle to be apparent on conventional word discrimination tests used clinically in optimal listening environments. As will be discussed, environmental conditions play an important role in the accuracy of speech perception.

Effects of environmental conditions

One of the most common complaints expressed by older individuals with hearing impairments is that they have considerably more difficulty understanding speech in the presence of background noise such as in a crowded room or in their home, when the television, radio or dishwasher is on. Bergman et al. (1976) found that scores on the C.I.D. Everyday Sentences test (Davis & Silverman, 1970) declined significantly with increasing age for listening conditions other than those which were optimal. This deterioration in performance occurred as early as the fifth decade with a sharp acceleration occurring in the seventh decade. Helfer and Wilber (1990) also found speech perception to decline with increasing age when tested under reverberation in quiet and with cafeteria noise. They concluded that both age and amount of peripheral hearing loss contributed to increased difficulty in the ability to understand noisy, reverberant speech. Concordant results were observed in the consonant identification abilities of individuals with bilateral sloping sensorineural hearing losses under suboptimal conditions (Givens and Jacobs-Condit, 1981).

This difficulty in understanding conversational speech in settings with competing ambient noise varied amongst individuals. According to Giolas (1982) this phenomenon was the consequence of an interaction between (a) competing primary signals, (b) the particular acoustics of the room, and (c)

the nature of the person's hearing impairment. The ratio between the intensity of the speaker's voice and the ambient noise level in the room was important. As the ratio becomes smaller the hearing impaired person will have more difficulty discriminating and understanding speech. As well, the reverberation characteristics of the room influenced speech perception since the room would reflect the sound energy of the ongoing speech signal creating a masking effect. A final factor affecting speech perception is the physical properties of the sound signal itself.

Acoustic parameters of sound.

Differences observed in the discrimination ability of hearing impaired individuals noted above were partially attributable to the phonemic composition of the stimuli used. Givens and Jacobs-Condit (1981) reported that individuals with sloping sensorineural hearing impairments experienced considerable difficulty identifying phonemes with more high frequency peak energy, including the following stimulus consonants: /f/, /s/, /ʃ/, /tʃ/, and /θ/. Other researchers have found similar results (Bergman, 1980; Corso, 1971; Gelfand et al., 1986; Preminger & Wiley, 1985). Preminger and Wiley (1985) found that subjects with high frequency sensorineural hearing impairments accurately identified more consonant-vowel syllables with low frequency energy concentrations than high frequency energy concentrations. Corso (1971) stated that "since presbycusis involves high tone hearing loss, discrimination is poorest for those consonants which have high frequency components in their acoustic patterns" (p. 97). Similarly, Bergman (1980) investigated the speech perception abilities of older clients without clinically significant hearing problems. A clear deterioration in speech perception was found when the frequencies above 2000 Hz were electronically filtered out.

Based on the above observations, speech perception for the sounds with high frequency peak-energy appeared to be dependent, in part on the reception of acoustic cues above 2000 Hz. The frequency of the energy peak of individual sounds was determined by the place of articulation, manner of production and presence or absence of voicing. Pickett (1980) in his acoustical analysis of fricative sounds found that as the point of constriction moves anteriorly in the oral cavity the energy peak of the noise burst increases. For example, the resonant frequency for /*ʃ*/ is 3000 Hz, 4000 Hz for /*s*/, 5000 Hz for /*θ*/ and 4500 to 7000 Hz for /*f*/. High frequency energy in speech carries more information on both consonants and vowels than low frequency energy (Ling, 1978). The low frequency energy (around 500 Hz) has the greatest amplitude; the spectrum of the level of conversational speech decreases toward higher frequencies at the rate of 9dB per octave (VanTasell, 1981). Therefore under normal circumstances, the more powerful sounds are detected and are more intelligible at lower intensities than are the weaker ones (Gelfand et al., 1981). In addition, consonants, which convey more meaning than vowels, have energy peaks at higher frequencies in comparison with vowels (Bergman, 1980; Pollack, 1988). As Mader (1984) so aptly summarized, "the sounds of consonants are essential to the meaning of words; unfortunately, these are the sounds that some elderly people have the most trouble hearing and discriminating" (p. 549).

In short, speech perception is dependent on the intactness of both the peripheral and central auditory systems, environmental conditions and the physical properties of sound. Speech discrimination abilities tended to decline with age (Corso, 1971; Feldman & Reger, 1967; Gang, 1976; Gelfand et al., 1986; Jerger, 1973; Nash & Wepman, 1973), although there was controversy as to whether this decline was attributable to the peripheral hearing loss alone

rather than to central deficits in the processing of speech stimuli (Grady et al., 1984). Adequate speech discrimination skills have been noted in many elderly people under optimal listening conditions (Katsarkas & Ayukawa, 1986), but suboptimal conditions such as in noisy and reverberant environments exacerbated discrimination difficulties of older people with hearing impairments (Bergman et al., 1976; Givens and Jacobs-Condit, 1981; Helfer and Wilber, 1990). The physical characteristics of the speech signal also influenced speech perception.

These factors interact to reduce the clarity of the signal received. Individuals with impaired hearing receive this distorted signal at a lesser intensity than that at which normal hearing listeners would receive the same message. For example, it is generally accepted that conversational speech is heard at approximately 45 dB HL. If a person had an audiometrically measured hearing level of 45 dB, that person would be hearing normal conversational speech faintly. Adding the potential distortion of the signal known as speech discrimination difficulties observed in many elderly individuals further complicates the picture. The reduced intensity and clarity of a spoken message received by a hearing impaired elder would affect communication skills, including the ability to repeat. However, the performance of elderly people with hearing impairments in the absence of neurologically induced language problems (i.e., aphasia) has yet to be investigated.

The Boston Diagnostic Aphasia Examination

The Boston Diagnostic Aphasia Examination (BDAE) (Goodglass & Kaplan, 1983) is a clinical and research assessment instrument frequently used by speech-language pathologists (Davis, 1983). A component of the Oral

Expression subtest of the BDAE (Goodglass & Kaplan, 1983) assesses a client's ability to accurately repeat high probability and low probability phrases and sentences. These sentences differ in "vocabulary difficulty and predictability of the verbal content" (Goodglass & Kaplan, 1983, p. 38). Essentially high probability sentences incorporate more frequently used words and more common expressions such as "You know how". Conversely, low probability sentences are more unusual although grammatically correct and possess words with lower frequency and probability of co-occurrences, for example, "The phantom soared across the foggy heath".

In order to better understand the clinical concerns to be expressed regarding the BDAE (Goodglass & Kaplan, 1983), the following information will be presented: (a) development of the BDAE, (b) incidence of stroke in older adults and implications for assessment, (c) the role of sentence repetition tasks in diagnoses, and (d) results of the BDAE normative study.

Development of the BDAE

The Boston Diagnostic Aphasia Examination (BDAE)(Goodglass & Kaplan, 1983) was developed during the 1960's. At that time the majority of patients with aphasia were under 65 years of age (Davis & Holland, 1981). During that period, hospital morbidity rates (per 100,000) tended to be higher in people 45-64 years than people over 65 years of age for admissions with diagnoses of cerebrovascular accidents (Dominion Bureau of Statistics, 1961). Individuals over the age of 65 tended to die from the cerebrovascular crisis rather than survive. Thus, the need for tests to discriminate the presence of additional complicating factors such as those associated with the aging process (e.g., hearing loss, presbyopia, poor memory and dementia) was not of major concern at the time of the test's development (Chapman, 1988).

Incidence of stroke in elders and implications for assessment

Since the BDAE (Goodglass & Kaplan, 1983) was developed, the incidence of cerebrovascular accidents and residual aphasia in the aged population has increased dramatically (Chapman, 1988; Metter, 1980; Miceli et al., 1981; Rau & Schulz, 1988; Wolf, Kannel & McGee, 1986). Wolf et al. (1986) stated that there was a doubling in the incidence of stroke for every decade over the age of 55 years. Based on annual incidence and prevalence rates of stroke, Metter (1980) estimated that "for a population of 230 million people approximately 1 million individuals at a given time will be living after suffering a stroke" (p. 141). This prediction was corroborated by a 1981 American Heart Association estimate that there were 1,870,000 American stroke survivors (Dyken et al., 1984), approximately 66% of which may have had a language impairment (Miceli et al., 1981). There has been a marked decline since 1968 in mortality rates from stroke in the elderly, particularly among the young elderly (Posner, Gorman & Woldow, 1984; Wilkins, Morris & Lane, 1988). More people are surviving the stroke and living with the residual effects.

Since people over 65 years of age represent a growing proportion of the Canadian population (Statistics Canada, 1987) and are also at most risk for cerebrovascular accidents (Metter, 1980; Posner et al., 1984; Wolf et al., 1986), current aphasia test batteries must have discriminatory power with these elderly subjects. To provide the speech-language pathologist with valid information these tests should differentiate deficits due to stroke-induced language impairment from declines associated with normal age-related or other co-existing factors (Chapman, 1988). In keeping with this, clinical concern has recently been expressed regarding the use of the Sentence Repetition

subtest from the BDAE (Goodglass & Kaplan, 1983) with elderly patients who have hearing impairments (Norman, 1988, October). Norman (1988, October) observed that there was a greater number of phonemes with high frequency peak-energy components in the low probability sentences ($n=20$) than in the high probability sentences ($n=10$). Based on the earlier discussion of speech perception, this fact may have deleterious effects on test performance by an older adult with a high frequency hearing impairment. Understanding the role of sentence repetition tasks in diagnoses will reinforce the importance of using assessment tools that have discriminatory power with the elderly.

Role of sentence repetition tasks in diagnoses

Sentence repetition tasks are important in the differential diagnosis of aphasia (Goodglass & Kaplan, 1983; Kertesz & Poole, 1982; Schuell, 1973) and cortical dementias (Bayles & Kaszniak, 1987; Obler & Albert, 1981). The diagnostic significance of these repetition tasks lies in its relation to performances on other language measures. The importance of sentence repetition tasks to the valid assessment of each of these disorders will be discussed separately.

Aphasia. Sentence repetition tasks are important in the differential diagnosis of aphasia (Goodglass & Kaplan, 1983; Kertesz & Poole, 1982; Schuell, 1973). Goodglass and Kaplan (1983) stated that repetition in aphasia may be disrupted at three levels in the process: recognition, articulation or selective dissociation between auditory input and speech output. Given this complexity, the diagnostic significance of this subtest depends on its relation to other performances. Results may help differentiate between Broca's

aphasia, Wernicke's aphasia, anomic aphasia, transcortical sensory aphasia, transcortical motor aphasia and conduction aphasia. For example, conduction aphasia is characterized primarily by an impairment of repetition that is disproportionately severe relative to the level of fluency in spontaneous speech and adequacy of auditory comprehension. Accuracy of repetition ability in conduction aphasics deteriorates as the stimulus becomes longer in length and the content becomes less familiar (Davis, 1983). "With short, familiar phrases, the repetition may contain one phonemic paraphasia [i.e., substitution, addition, or rearrangement of speech sounds so that the error can be identified as sounding like the intended word]. However, as stimuli increase in difficulty, the phonemic paraphasias increase until output is reduced to random neologistic forms [i.e., a fluently spoken invented word]" (Davis, 1983, p.21). Accurate appraisal of language skills are essential in determining a diagnosis and choosing an appropriate treatment approach (Davis & Holland, 1981; Rosenbek, LaPointe & Wertz, 1989). As Blair (1990) indicated, a clinician's inability to differentiate normal physiological changes of aging from those associated with disease may result in misdiagnosis and mismanagement of the elderly client.

Dementia. Sentence repetition tasks are also utilized in the differential diagnosis of cortical dementias (Bayles & Kaszniak, 1987; Obler & Albert, 1981). According to Obler and Albert (1981), an individual with early-stage Alzheimer's dementia will accurately repeat long high probability sentences but will perform less well on the repetition of shorter low probability sentences. "With these low probability sentences, patients will look confused and repeat related sounds or words of the same or slightly shorter syllable length as the stimulus item (e.g., He bride the tid lid [as opposed to 'He pried

the tin lid off]" (p. 390). Such substitution errors could also be produced by a hearing impaired individual who relies on speech reading as the substituted sounds are homophenous (i.e., made at the same point of articulation thereby appearing the same visually).

A comparative study among normal elderly subjects, subjects with mild senile dementia of the Alzheimer's type (SDAT) and subjects with moderate SDAT indicated that all groups repeated the high frequency sentences from the BDAE (Goodglass & Kaplan, 1983) equally well (Rosen, 1983). However, on the low frequency sentences individuals with mild SDAT performed significantly worse in comparison with the normal elderly group. There was also a significant difference between performance on the low frequency and high frequency word sentences by people with mild SDAT. As the dementia progressed, performance deteriorated on the high probability items as well as the low probability items (Cummings, Benson, Hill & Read, 1985; Obler & Albert, 1981; Rosen, 1983). Obviously, individuals with acquired language impairments due to cerebral infarcts or dementia have difficulty with sentence repetition tasks, but how do healthy older individuals perform on these tasks?

Results of the BDAE normative study

Borod, Goodglass and Kaplan (1980) normed 24 subtests (including the Sentence Repetition subtest) of the BDAE (Goodglass & Kaplan, 1983) on 147 normal, non-hospitalized adult males between the ages of 25-85 years. The description of subjects was incomplete; the hearing status of participants was omitted. These researchers found that, in general, subjects with low scores were invariably over 60 years of age with fewer than 9 years of formal education. Specifically, on the low probability sentences a significant difference among age groups was found favoring the younger age groups; on

the high probability sentences there was a significant difference among age groups without a consistent trend favoring one end of the age spectrum. There was no main effect on either high or low probability sentence type for level of education. These researchers concluded that a lower cut-off score [2 standard deviations below the mean (6 of 8 correct)] should be used on the low probability sentence repetition task with patients over the age of 60 years. An alternative explanation for these results may be that the poorer repetition performance of elderly subjects compared to younger subjects was related to reduced hearing sensitivity rather than age alone. This hypothesis is plausible because no information was provided on the hearing acuity of participants from the normative study.

Corroborative evidence for this position was provided by a study on the speech perception abilities of older adults. Bergman et al. (1976) reported that older adults (aged 70-79 years), without clinically significant hearing losses, were able to repeat ten undistorted sentences in quiet conditions from the C.I.D. Everyday Sentence List (Davis & Silverman, 1970) with 94% accuracy. Reassessment 3 years later indicated that there was no significant change in individuals' understanding of, and therefore ability to repeat, these control sentences. This result suggests that the ability to repeat sentences is not affected by the variable age, rather a second factor which may be associated with the aging process is producing the difference observed by Borod et al. (1980).

In summary, results from sentence repetition tasks, such as the BDAE Sentence Repetition subtest (Goodglass & Kaplan, 1983) in relation to performances on other language tasks are applied to the differential diagnosis of aphasia (Goodglass & Kaplan, 1983; Schuell, 1973) and cortical dementias (Bayles & Kaszniak, 1987; Obler & Albert, 1981). These disorders which

affect communication occur predominantly later in life (Chapman, 1988; Metter, 1980; Miceli et al., 1981; Rau & Schulz, 1988; Wolf et al., 1986). Concern was expressed regarding the potential lack of discriminatory power of aphasia tests developed during the 1960s (Chapman, 1988; Norman, 1988, October). Such tests were not designed to differentiate between changes caused by the stroke from changes associated with the aging process or other complicating factors. Accurate assessment and diagnosis of individuals' with aphasia is vital in determining appropriate treatment (Davis & Holland, 1981; Rosenbek et al., 1989).

Knowing how healthy older people perform on aphasia test batteries assists clinicians in distinguishing between age-related changes in communication and differences due to disease processes. Borod et al. (1980) provided initial normative data for the BDAE (Goodglass & Kaplan, 1983). These researchers found a main effect for age on the low probability sentence repetition task favoring the younger age groups. Therefore they suggested a lower cut-off score be used for people over the age of 60 years. However, hearing sensitivity, which was a potentially confounding variable, particularly in elderly subjects, was omitted from their research design. A second study found contradictory results (Bergman et al., 1976). Therefore the results observed by Borod et al. (1980) may be accounted for partly by the reduced auditory acuity of participants, rather than their age alone.

Pilot Study

Eales-Forward (1989, April) in a preliminary investigation, examined the effects of presbycusis hearing loss on the performance of nine healthy neurologically intact older adults (aged 65-77 years) on the BDAE (Goodglass & Kaplan, 1983) sentence repetition subtest. Comparisons were made

between normal hearing ($n=4$) and hearing impaired ($n=5$) elders on their ability to accurately repeat high and low probability sentences from the BDAE (Goodglass & Kaplan, 1983). Analysis of variance indicated no difference in performance on the two sentence types and no interaction between hearing status and sentence type. Comparison of overall performance between the two groups ($F(1,7)=4.32, p=.087$) implied that hearing acuity may have influenced subjects' sentence repetition task performance. Hearing impaired seniors tended to have lower overall scores than their normal hearing peers.

This latter result suggested an alternative explanation for the findings reported by Borod et al. (1980) who hypothesized that depressed scores on the low probability subtest were related to aging. In the Eales-Forward (1989) study, all normal hearing seniors obtained maximum scores ($M_d=8$) on the low probability sentences, while hearing impaired seniors obtained scores ranging from 6-8 ($M_d=7.25$). Based on these observations, the author suggested that differences in sentence repetition performance among aged adults may be associated with reduced hearing sensitivity rather than age alone. However, interpretation of these results must be tempered by the recognition that the trends were found on a small sample and statistical analysis failed to reach a traditionally acceptable alpha level.

Conclusion

Considering the documented decline in auditory acuity and speech perception associated with the aging process, there is justifiable concern that elderly patients with presbycusis hearing losses may be unfairly disadvantaged on the sentence repetition subtest of the BDAE (Goodglass & Kaplan, 1983). In summary, it was found that both hearing acuity (Feldman & Reger, 1967; Grady et al., 1984; Harford & Dodds, 1982; Jerger, 1973;

Katsarkas & Ayukawa, 1986; Kryter, 1983; Lebo & Reddell, 1972; Patterson et al., 1982; Robinson & Sutton, 1978; Schow & Nerbonne, 1980; Spoor, 1967) and speech discrimination ability (Corso, 1971; Feldman & Reger, 1967; Gang, 1976; Gelfand et al., 1986; Jerger, 1973) declined with age; their most deleterious effects being on the phonemes with peak-energy in the high frequencies (Bergman, 1980; Corso, 1971; Gelfand et al., 1986; Givens & Jacobs-Condit, 1981; Preminger & Wiley, 1985). The incidence of cerebrovascular accidents (Metter, 1980; Posner et al., 1984; Wolf et al., 1986) and resultant aphasia (Chapman, 1988; Miceli et al., 1981; Rau & Schulz, 1988) also increased with age. The resultant language impairment requires evaluation with appropriate assessment tools, however, concern has been expressed regarding the discriminatory power of current aphasia assessment tools, including the BDAE (Goodglass & Kaplan, 1983) (Chapman, 1988; Norman, 1988).

Accordingly, it appears probable that the trends observed in the BDAE (Goodglass & Kaplan, 1983) normative study by Borod et al. (1980), namely the significant negative relationship found between age and low probability sentence repetition performance in the absence of control for hearing sensitivity, may be due to a decline in auditory acuity associated with the aging process rather than the generic variable age. Initial findings from a pilot study of the sentence repetition ability of adults (65-77 years) with normal hearing and hearing impairments tended to support this theory (Eales-Forward, 1989). It may be hypothesized that, there is a difference in BDAE (Goodglass & Kaplan, 1983) sentence repetition ability between individuals with normal hearing and degrees of hearing impairment when the age of subjects is restricted. In addition, hearing impairment may interact with performance on the low probability sentence items. If this hypothesis is

confirmed, it will emphasize the need to improve assessment methods for use with elderly patients having coexisting aphasia and hearing loss.

Statement of Research Questions

From the above discussion it is evident that hearing loss associated with the aging process may be an influential factor in elderly persons' abilities to repeat sentences. This study was designed to test the effect of differential hearing acuity on the ability of healthy elderly individuals to repeat the high- and low-probability sentences from the BDAE (Goodglass & Kaplan, 1983). Since reduced hearing sensitivity is prevalent among non-aphasic and aphasic elderly adults alike, evidence of an effect for reduced hearing acuity would place the discriminative qualities of this subtest in question. Specifically, the present study was designed to answer the following questions:

1. What is the effect of hearing acuity on healthy elderly adults' responses to the sentence repetition task of the BDAE (Goodglass & Kaplan, 1983)?
2. What is the effect of sentence probability on healthy elderly adults' responses to the sentence repetition task of the BDAE (Goodglass & Kaplan, 1983)?
3. Is there an interaction between level of hearing acuity and sentence probability on healthy elderly adults' responses to the sentence repetition task of the BDAE (Goodglass & Kaplan, 1983)?

Chapter III. Methodology

Subjects

Forty-five elderly adults living independently in the community volunteered to participate in the study. Twelve of these individuals were found to be inappropriate for inclusion for the following reasons; four had significant neurological histories such as known occurrences of cerebrovascular accidents (CVA) or transient ischemic attacks (TIA), two had diagnoses of Meniere's disease, one reported a unilateral hearing loss of sudden onset, four were in questionable physical health, and one had a failed score on the Short Portable Mental Status Questionnaire (Pfeiffer, 1975).

Participants who met all of the inclusion criteria were 25 females and eight males ranging in age from 68 to 89 years ($M = 75.24$ years; $S.D. = 5.34$). Sixteen participants were recruited from local senior citizens' centers and senior citizens' recreation clubs; the remainder were obtained from intersubject referrals. Thirty-two people were native speakers of English. One participant was French Canadian and had learned English at the age of eight years but was retained, because childhood exposure to a language other than English does not appear to affect elderly adults' abilities to imitate complex syntactic sentences (Kemper, 1986). Participants had an average of 12 years of formal education ($S.D. = 2.789$), with a range of 8 to 18 years.

Medical history, information required to estimate cognitive level (IQ) and speech discrimination abilities were not used as exclusion criteria but were obtained from each participant and recorded. Medical histories and information needed to estimate IQ were obtained to estimate the representativeness of participants with respect to their peers. Speech discrimination was used as a covariate in the statistical analysis of the data.

Exclusion on the basis of maladies common in the elderly, such as hypertension or heart disease (Dyken, 1987; McDevitt, 1984; O'Callaghan, O'Brien & O'Malley; Warlow et al., 1987; Whisnant, 1987), may have restricted the subject sample to "supernormal" older adults not representative of the typical aged population (Weismer & Fromm, 1983, page 318). Collective medical histories of participants in this study included hypertension, diabetes, arthritis, myocardial infarction, use of a pacemaker and thyroid gland disorders.

Hearing status, self-perceived physical health, current medications and mental status determined which participants were included in this study.

Hearing Status

All participants who were judged to have a hearing impairment had a bilateral, high frequency hearing loss. The difference in high frequency pure tone average (HFPTA) (American Speech & Hearing Association [ASHA], 1989; Bess, Lichenstein, Logan & Burger, 1989) between ears for all participants ranged from 0 to 26, with a mean difference of 7.64 ($S.D.$ = 7.34). HFPTA was the average of pure tone air conduction thresholds in the better hearing ear at 1000, 2000 and 4000 Hz. All participants exhibited less than a 15 dB difference between air conduction and bone conduction thresholds at all frequencies tested (M = 6.36; $S.D.$ = 3.37). One volunteer wore hearing aids on a regular basis; two volunteers wore hearing aids infrequently (e.g., only to meetings).

Participants were grouped according to unaided HFPTA in the better hearing ear as follows:

- (a) Normal hearing group: 19 people had HFPTA less than 25 dB HL,
- (b) Mild hearing impaired group: 11 people had HFPTA between 26 - 40 dB HL,
- (c) Moderate hearing impaired group: 3 people had HFPTA between 41 - 55 dB HL.

High frequency pure tone average was chosen as a grouping variable rather than the standard pure tone average (based on thresholds at 500, 1000 and 2000 Hz) since several studies (Cervellera & Quaranta, 1982; Elliott et al., 1985; Kryter, 1983; Patterson et al., 1982) found that older people exhibited a greater difference in hearing threshold level at 4000 Hz than was reflected by the standard pure tone average alone (Duquesnoy, 1983; Katsarkas & Ayukawa, 1986). In the pilot study for this project (Eales-Forward, 1989), high frequency pure tone average was found to discriminate between normal hearing and hearing impaired seniors [$t(7) = -3.762, p = .007$], whereas standard pure tone average did not [$t(7) = -1.15, p = .2876$].

Subjective Health

Participants were in good perceived health as determined by a self-rating consistent with the procedures of Maddox and Douglass (1973). In a longitudinal study of elderly patients these researchers found that patient and physician independent ratings of patients' health were congruous on 95% of the assessments; only 5% were extremely incongruous. These authors reported that "good" health implied the absence of debilitating illness that significantly interfered with personal and social functioning rather than the

absence of morbid conditions. They concluded that self-ratings of health have utility in research when objective measures of health are not feasible. Other investigations (Ferraro, 1980; LaRue, Bank, Jarvik & Hetland, 1979; Suchman, Phillips & Streib, 1958; Tissue, 1972) yielded corroborative findings.

Accordingly, participants were asked on a written questionnaire (Appendix B) "How do you rate your health at the present time?" A choice of four descriptors were offered (excellent, good, fair, poor). Those subjects who responded "fair" or "poor" were classified as subjectively in poor health in accordance with the recommendations made by Maddox and Douglas (1973) and thus excluded from the study. Four subjects were excluded from the study for "fair" self-assessments of physical health. The remaining participants responded with either "good" or "excellent" descriptors.

Medications

A list of current medications were obtained as some drugs may affect mental status or short term memory and potentially hinder optimal performance on the experimental task (Friesen, 1983; Krogh, 1988; Simonson, 1984; Sumner, 1983). Volunteers were asked on a written questionnaire (Appendix B) if they were currently taking antidepressants (e.g., Nardil, Parnate, Desyrel, Tofranil or Asendin), barbituates (e.g., Seconal, Nembutal), anorexiant (e.g., Pondimin, Ionamin) or anticholinergics (e.g., Cogentin, Atropine). These drugs are known to cause forgetfulness in some individuals (Friesen, 1983; Krogh, 1988; Simonson, 1984). All participants reported that they were not taking any of these medications.

Mental Status

The Short Portable Mental Status Questionnaire (SPMSQ) (Pfeiffer, 1975) (Appendix A) was used to screen the intactness of intellectual functioning in participants in order to exclude those volunteers with possible confusion or early dementia. Good reliability and validity have been established for this instrument (Fillenbaum, 1980; Pfeiffer, 1975). There was 92.3% agreement between the SPMSQ score and the clinical diagnosis of organic brain syndrome (OBS) when the SPMSQ indicated definite impairment (Pfeiffer, 1975). In a second study, the SPMSQ accurately identified 96% of participants without a clinical diagnosis of OBS (Fillenbaum, 1980). Correlations between SPMSQ scores given to subjects twice at four week intervals indicated strong test-retest reliability ($r = .83$) (Pfeiffer, 1975). Norms adjusted for race and education have been developed (Pfeiffer, 1975).

The SPMSQ was administered and scored according to the instructions outlined by Pfeiffer (1975); two questions were adapted for Canadian content. Individuals with three or more errors (mild or greater intellectual impairment) on the 10 item questionnaire were excluded from the study. One individual who failed to meet this criterion was excluded from the study. Remaining subjects were considered to have intact intellectual functioning ($M = 9.36$; $S.D. = .783$). A summary of subject information is presented in Table 1.

Table 1. Summary of subject information

Factor	Normal Hearing Mean (S.D.)	Mild Hearing loss Mean (S.D.)	Mod. Hearing loss Mean (S.D.)
Age	74.00 (4.00)	77.00 (7.16)	76.67 (4.62)
Estimated IQ	109.68 (8.29)	106.54 (6.35)	112.67 (12.66)
Education (years)	12.53 (2.86)	11.27 (2.28)	13.33 (4.16)
SPMSQ	9.58 (0.61)	9.00 (0.89)	9.33 (1.15)
Speech Discrim.	98.74 (2.33)	98.54 (2.02)	96.00 (4.00)

In summary, participants were 33 elderly adults (male and female) aged 68-89 years living independently in the community with no known history of cerebrovascular accident or other neurological disease. By self-perception participants were in "excellent" or "good" health (Maddox & Douglass, 1973) and responded with 2 or fewer errors on the SPMSQ (Pfeiffer, 1975) mental status screen. In addition, participants were not taking medications such as antidepressants, barbituates, anorexians or anticholinergics which might have adversely affected cognition and task performance. Participants were not excluded from the study on the basis of high frequency pure-tone average, because a wide continuum of hearing acuity was desired. Those subjects with confirmed hearing impairment evidenced a bilateral, symmetrical, sensorineural hearing impairment.

Instrumentation and Materials

Instrumentation required to carry out the study included an audio-cassette recorder and tapes, a microphone and an audiometric sound suite equipped with a clinical audiometer. An electret condenser microphone (Akai ACM-100) connected to an audio-cassette recorder (JVC PC-2VC) was used to

record participants' responses on high fidelity chrome cassette tapes (TDK SA90). The impedance of the microphone matched that of the audio-recorder's input amplifier.

All audiometric testing was performed in an audiometric sound suite (Genie Audio S121P) at a local hospital. A clinical audiometer (Madsen OB 822) calibrated to ANSI-1969 standards within sixteen months of testing generated pure tones needed to determine individuals' hearing threshold levels bilaterally under headphones. A dual audio-cassette recorder (JVC TD-W101) coupled to the clinical audiometer was used to play standardized pre-recorded stimuli (Auditec recordings) required to measure SRT and word recognition scores free field through a single monitoring speaker (EV MS-802).

The SPMSQ (Pfeiffer, 1975) was used to screen participants' mental status prior to task administration (Appendix A). Standardized audio-recordings made by a male speaker of the C.I.D. Auditory Test W-1 (Hirsh et al., 1952) spondaic word list (Appendix C) and the C.I.D. Auditory Test W-22, 4A (Hirsh et al., 1952) phonetically balanced word list (Appendix D) were used to measure participants' SRT and speech discrimination abilities respectively. The stimuli from which the dependent variable responses were derived were the high- and low- probability sentences from the BDAE (Goodglass & Kaplan, 1983) Sentence Repetition subtest (Appendix E). The validity and reliability of this assessment tool will be discussed further.

Validity of the BDAE

The BDAE (Goodglass & Kaplan, 1983) is among the most comprehensive of aphasia test batteries. It has been listed as one of the most worthy aphasia tests to be developed (Darley, 1977). It was designed to meet three general purposes: "(1) diagnosis of presence and type of aphasic

syndrome, leading to inferences concerning cerebral localization; (2) measurement of the level of performance over a wide range, for both initial determination and detection of change over time; (3) comprehensive assessment of the assets and liabilities of the patient in all language areas as a guide to therapy" (Goodglass & Kaplan, 1983, p. 1).

The BDAE (Goodglass & Kaplan, 1983) diagnostic test was initially standardized on 207 aphasic patients (Goodglass & Kaplan, 1972). The BDAE was later restandardized on a new sample of 242 aphasic patients as the scoring system was revised in the second edition of the test (Goodglass & Kaplan, 1983).

Construct validity for identifying syndromes was determined by factor analysis of the data used for standardization of the second edition of the BDAE (Goodglass & Kaplan, 1983). Factor analysis identified subsets of subtests which tapped similar underlying constructs. Factor analysis based on inclusion of all language tasks and supplementary nonlanguage tasks isolated ten factors: Spatial-quantitative, Fluency, Repetition-recitation, Auditory comprehension, Writing, Verbal paraphasia, Nonverbal oral agility, Finger identification, Naming, and Freedom from paraphasia. A second factor analysis of only the language measures isolated seven factors with eigenvalues ranging from 2.5 to 12.0. The Repetition-recitation factor (Factor 3), which represented operations involving voluntary speech production, included sentence repetition subtest scores. It was the factor having the largest eigenvalue of 12.0, indicating that it had the highest "relative importance" from among the seven language factors (Nie, Hull, Jenkins, Steinbrenner, & Bent, 1975, p. 442).

There is a lack of information on the predictive validity of the BDAE (Goodglass & Kaplan, 1983). According to Duffy (1979) the BDAE was not

designed to have predictive validity as a measure of prognosis for language recovery.

Concurrent criterion validity, as a measure of aphasic communicative ability, was established by Holland (1980). Holland found that there was a strong correlation ($r=.84$) between the BDAE and the Communication Abilities in Daily Living (CADL) test (Holland, 1980). The BDAE correlated weakly ($r=.49$) with Holland's criterion measure of communication ability in everyday situations. Thus, there is a strong correlation between formal test scores but not between the BDAE (Goodglass & Kaplan, 1983) and scores reflecting communication ability of aphasics in more naturalistic contexts. Ulatowska, Macaluso-Haynes & Mendel-Richardson (1976) also found no significant correlation between total score on selected BDAE subtests and home visit scores.

Reliability of the BDAE

The Kuder-Richardson method of determining inter-item reliability was applied to test scores of 34 patients with varying degrees of severity of aphasia (Goodglass & Kaplan, 1983). The Kuder-Richardson reliability coefficient is mathematically equivalent to the mean of all split-half coefficients resulting from different divisions of the test. Reliability coefficients for 20 of the 21 subtests examined ranged from $r_{xx} = .80$ to $.98$, 14 of which were $.90$ or higher. The reliability coefficients for the high and low probability sentence repetition subtest were $.90$ and $.91$ respectively.

Inter-examiner reliability of the Profile of Speech Characteristics rating scales was determined by computing Pearson product moment correlations (Goodglass & Kaplan, 1983). The two most disparate ratings of three judges who listened to tape-recorded conversations of 99 subjects were used in the

computations. Correlation coefficients for ratings of six dimensions of oral language ranged from .78 to .90, four of which were .85 or higher. The comparatively low reliability of the Paraphasia and Word Finding ratings was associated with the subjectiveness of the judges in making these ratings (Goodglass & Kaplan, 1983). A study by Ulatowska et al. (1976) provided inter-examiner reliability on 12 of the BDAE subtests, including the Sentence Repetition subtest. These researchers found complete agreement by three examiners on 76% of the test items, a one point discrepancy in scoring on 22% of the items, and a two point discrepancy on 1.7% of the items.

Formal test-retest reliability has not been investigated with the BDAE since there is considerable variability in the performance of aphasic individuals in repeatability of test results (Goodglass & Kaplan, 1983). For example, many patients have fluctuations in abilities from day to day as well as fluctuations within a single day itself.

In summary, the BDAE appears to have good construct validity, criterion-related validity, internal consistency and inter-examiner reliability (Goodglass & Kaplan, 1983; Holland, 1980). It reportedly has acceptable content validity as a test of language abilities (Duffy, 1979). It was standardized on a relatively large aphasic population (Goodglass & Kaplan, 1972; Goodglass & Kaplan, 1983) and normative data are available (Borod et al., 1980).

Procedures

Evaluation of the inclusion criteria and administration of the experimental procedures was performed in either one 90-minute session or two 45-minute sessions as desired by individual participants. The majority of participants were seen in one contact in a quiet clinical environment at a local hospital. Two participants were seen across two sessions. In these cases, the first

session was conducted at the participants' homes; the second session was conducted at the local hospital. All participants were given the same procedures.

Initial interview

During the initial session the experimenter explained the purpose and procedures of the study to the volunteer and obtained written consent for participation (Appendix F). The consent form was written utilizing short, simple, grammatical constructions with words having high frequency of usage (Tymchuk, Ouslander & Rader, 1986). It was typed using large print letters in accordance with recommendations for enhancing the understanding of elderly research subjects (Ratzan, 1986; Taub, Baker, Kline & Sturr, 1987). Taub et al. (1987) found that older subjects (80-89 years) answered multiple choice questions (from a choice of five alternatives) based directly on a research study's information sheet more accurately ($p < .01$) when the information sheet was written with a larger (10 pitch) typeface than with smaller (12 pitch) typefaces. Participants completed a written health questionnaire to obtain information about significant medical history, current medications and self-perceived physical health (Appendix B).

A regression equation differentially weighting age, sex, race, years of formal education and occupation was used to estimate subjects' levels of intelligence (IQ). This formula, developed by Wilson, Rosenbaum and Brown (1979), was based upon a regression equation derived from analysis of the original WAIS standardization data. Wilson and his colleagues (Wilson, Rosenbaum, Brown, Rourke, Whitman & Grisell, 1978) recommended a correction factor for education (0.82) be applied to the original equation, however, subsequent studies (Goldstein, Gary & Levin,

1986; Karzmark, Heaton, Grant & Matthews, 1985) have found this adjustment to result in a less accurate estimate of mean full scale IQ. The regression equation developed by Wilson et al. (1979) has been validated by Goldstein et al. (1986) and Karzmark et al. (1985).

$$\text{I.Q. estimate} = .17 (\text{age}) - 1.53 (\text{sex}) - 11.33 (\text{race}) + 2.97 (\text{years of education}) + 1.01 (\text{occupation}) + 74.05$$

Information required to complete this equation was obtained verbally during the initial interview. Respondents had a mean estimated full scale I.Q. of 108.90 (S.D.=8.056; range=97-127). In addition, participants were asked if they were native English speakers.

Hearing aid check

Hearing aids worn by two participants were checked for adequate functioning at the start of the session by repeating the Ling Five-Sound test (Ling, 1978) while listening to the hearing aid through a hearing aid stethoscope. The phonemes /a/, /u/, /i/, /s/ and /ʃ/ were repeated to determine whether the hearing aid permitted optimum detection of all aspects of speech. This practical test was considered a reliable check on the frequency responses of a hearing aid, because the five sounds employed "encompass the frequency range of all phonemes and the voiced sounds contain sufficient harmonics to convey suprasegmental information" (Ling, 1978, pp. 195-196). The five sounds were amplified without perceived distortion. Batteries were replaced in the hearing aids, if they had not been replaced within two days of the test date. All hearing aids appeared to function adequately.

Administration of the mental status screen

Administration of the SPMSQ (Pfeiffer, 1975) mental status screening followed the initial interview and hearing aid check as applicable. The SPMSQ was given according to the instructions outlined by Pfeiffer (1975). Participants were asked a series of twelve questions. Two of the questions were adaptations of original questions reworded to reflect Canadian content (Appendix A). Answers were transcribed verbatim. To be scored correct accurate responses had to be given without reference to a calendar, birth certificate or other aid to memory. Responses were scored according to the guidelines given by Pfeiffer (1975). It was found that participants were more accurate in recalling the names of Presidents of the United States than Prime Ministers of Canada. Since these two questions were designed to test orientation (Pfeiffer, 1975), all participants' responses for these questions were scored on the basis of their accuracy in remembering current and immediate past Presidents of the United States rather than their Canadian counterparts. Therefore, total number of errors were tabulated for individuals' responses to the original ten questions.

Administration of the BDAE Sentence Repetition subtest

During the administration of the BDAE (Goodglass & Kaplan, 1983) experimental task clients were seated directly opposite the examiner in order to parallel traditional diagnostic test conditions and to optimize the perception of speech reading cues (Romano & Berlow, 1974; Alpinier, 1982). Participants sat in front of a microphone connected to an audio-cassette recorder. The microphone was held in a stand angled at approximately 60 degrees and positioned 12-15 inches from the client's mouth for optimal recording of

responses. Responses were audio-recorded for later calculations of inter- and intra-judge reliability.

The BDAE (Goodglass & Kaplan, 1983) sentence repetition task was administered according to the directions given by Goodglass and Kaplan (1983). Specifically, participants were instructed to listen carefully then repeat exactly what they heard. Sentences were presented live by a female speaker alternating between high-probability and low-probability sentence types. Each sentence was read clearly as an uninterrupted unit with a vocal presentation level of approximately 65 dB SPL (normal conversational loudness). A sound level meter was not used for monitoring this task since Stathopoulos (1985) found that maintenance of a comfortable speech loudness was as effective as visual monitoring in controlling vocal variability. A slightly reduced speaking rate was used to accommodate the mild slowing of information processing in the elderly (Chafetz and Wilson, 1988; Schmitt & McCroskey, 1981). The speaking rate was reduced by slightly lengthening the time interval between words. On verbal request, a single repetition of the entire test sentence was provided without penalty (Goodglass & Kaplan, 1983). The BDAE was administered prior to the evaluation of individuals' auditory acuities for the purpose of reducing any potential examiner bias (Lass, Browning & Brown, 1975).

Measurement of pure tone thresholds

Participants were then seated in the audiometric sound suite that was used for determining pure tone thresholds, SRT and speech discrimination ability. Daily preoperational checks were performed in accordance with CSA Standard Z 107.4 (1983) as applicable prior to all audiological evaluations. Air conduction threshold levels at 1000 Hz, 2000 Hz and 4000 Hz were measured

bilaterally under headphones using the 5 dB ascending presentations method reported by Carhart and Jerger (1959) and recommended by the American Speech and Hearing Association (ASHA) (ASHA, 1978). Threshold was defined as the level at which the participant responded to three stimulus presentations at a single intensity (Carhart & Jerger, 1959). Bone conduction thresholds were measured at each frequency in the better hearing ear with a bone-conduction vibrator using the same methodology. A pure tone audiogram was generated and HFPTA calculated for each subject using the better ear's thresholds at 1000, 2000 and 4000 Hz (ASHA, 1989). This figure was used to assign volunteers to one of three independent groups based on level of hearing acuity.

Measurement of speech discrimination skills

Word recognition score was obtained for all participants since speech perception abilities may vary across elderly individuals irrespective of level of peripheral hearing impairment (Willeford, 1978). This score was obtained as a potential covariate to account for differing speech discrimination abilities across subjects.

Word recognition score was measured in two steps: (a) speech reception threshold (SRT) was determined first according to an adaptation of the guidelines published by ASHA (1988), (b) word recognition (i.e., speech discrimination) score was measured 45 dB HL above SRT or at individuals' most comfortable listening level (Beattie & Warren, 1983). Audiorecordings were calibrated using the 1000 Hz calibration tone prior to each use.

SRT was established using the recorded C.I.D. W-1 spondaic word list (Hirsh et al., 1952) (Appendix C) according to a modified version of the ASHA guidelines for determining threshold level for speech (ASHA, 1988).

The procedures were adapted in consultation with a clinical audiologist to minimize the time required to complete the task. There was concern that the prescribed ASHA method would force elderly individuals to listen to many stimuli below their threshold resulting in fatigue and frustration.

Initially, participants were familiarized with a typed alphabetized list of the spondaic words. The audio-recording was calibrated to the speech audiometer, and the stimuli were presented free field through one speaker. Individuals were seated one meter from the speaker facing the sound source. Participants were instructed to repeat each of the two-syllable compound words presented to them even though they may have to guess at some of them. One word was presented 30 dB above individuals' pure tone thresholds at 1000 Hz and at each 10 dB attenuation until a word was incorrectly repeated. A second word was then repeated at this last intensity level. If the word was repeated accurately the intensity was further reduced 10 dB and the procedure repeated. If the word was missed the intensity was increased 5 dB and four words were presented. The threshold for speech was defined as the lowest level at which 50% or more of the spondee words were correctly identified (ASHA, 1988).

The first half (#1-25) of an audiorecording of the C.I.D. W-22 (Hirsh et al., 1952) phonetically balanced word list (Appendix D) was then used to obtain an optimal unaided speech discrimination score (PB_{max}) in sound field. Researchers have found reliable concordance between scores based on full and abbreviated discrimination tests (Elpern, 1961; Penrod, 1980). Participants were instructed to repeat one-syllable words presented at a constant loudness level. Stimuli were delivered free field through one speaker at a sensation level of 45 dB above SRT. This level was deemed the most appropriate sensation level to use with hearing impaired elderly when

estimating maximum intelligibility scores (Beattie & Warren, 1983). If an individual experienced recruitment, a growth in the perceived loudness of a sound disproportionate to the actual increase in the sound level, the constant loudness level was adjusted to a most comfortable loudness (MCL) level determined by each individual. For those participants who found the initial level too loud the MCL was always within 10 dB of the presentation level recommended by Beattie and Warren (1983). Occasional audiorecordings of participants' responses were made for later reliability judgements of speech discrimination.

Reliability Measures

The entire sentence imitation task was audio-tape recorded in order to calculate interjudge and intrajudge reliability. All audio samples were played back at a comfortable listening level determined by the second judge.

Interjudge reliability

Interjudge reliability was calculated from item-by-item comparison of a second speech-language pathologist's decisions on a random sample of 27% of the taped responses with those of the examiner on initial testing. The entire sample of taped responses was not used, since Ulatowska et al. (1976) in their investigation of the inter-examiner reliability of 12 of the BDAE subtests found complete agreement by three examiners on 76% of the test items and a one point discrepancy in scoring on 22% of the items. Total number of agreements tabulated across nine random samples were divided by the total number of agreements and disagreements to yield an overall interjudge reliability ratio. Interjudge reliability was 98.61%.

Interjudge reliability of the speech discrimination score was also calculated. Point-to-point comparisons were computed for the examiner's online word recognition score and the score obtained from transcriptions made by a second speech-language pathologist on 27% of audiotaped samples. Total number of agreements tabulated across nine random samples were divided by the total number of agreements and disagreements to yield an overall interjudge reliability ratio. Interjudge reliability on speech discrimination scores was 99.00%.

Intrajudge reliability

Intrajudge reliability was determined from item-by-item comparison of the examiner's online scoring and scoring obtained at least two weeks after initial testing on a random sample of 27% of audiotaped transcripts. Total number of agreements tabulated across nine random samples were divided by the total number of agreements and disagreements to yield an overall intrajudge reliability ratio. Intrajudge reliability was 98.61%.

Data Analysis

Subject's raw scores on the high- and low-probability sentences were tabulated independently; one point was given for each sentence correctly repeated. An accurately repeated sentence was defined as repeating every word of the target sentence correctly in the correct syntactic order.

An F-max test for homogeneity of variances was calculated on the raw scores from the sentence repetition task for the three independent groups, formed on the basis of hearing acuity, to see whether the three samples were likely drawn from the same population. Nonparametric tests were considered for data analysis, because the dependent variable (repetition score) represented

a skewed, ordinal level of measurement. However, traditional nonparametric tests available with standard computer software packages do not allow analyses of interactions in a mixed design nor inclusion of covariates (Siegel, 1956). Since the focus of the study was on a potential interaction between sensorineural hearing loss and sentence probability and since the study included a covariate, a parametric analysis of covariance (ANCOVA) was chosen over the nonparametric tests that might have been better suited to data having the median as their best index of central tendency.

Sentence repetition scores were subjected to a 3×2 analysis of covariance (ANCOVA) to look for main effects for between group variable A, level of hearing acuity, and within group variable B, sentence type, as well as an interaction between hearing acuity and sentence type. Optimal unaided speech discrimination score (PB_{max}) was used as a covariate. Post hoc analyses were used as necessary to clarify results of the ANCOVA.

Chapter IV. Results

An F-Maximum test for homogeneity of variances calculated on participants' high and low probability sentence repetition scores was non-significant ($F_{max}(18) = 2.430, p > .05$). This indicated that the three independent groups based on hearing acuity were likely drawn from the same population in terms of their sentence repetition scores.

In order to control for the effects of aging as found by Borod et al. (1980) a *t*-test for paired samples was performed on overall sentence repetition scores for Young-Old (68-78 years) and Old-Old (79-89 years) respondents matched on the basis of HFPTA in the better ear. The mean difference in HFPTA between the matched pairs was 3.25 ($S.D.=3.454$) with a range of 0-9. This analysis was performed utilizing the StatView SE+Graphics computer program (Feldman, Hofmann, Gagnon & Simpson, 1988). Results were nonsignificant, $t(7) = .357, p = .7318$, which indicated that there was no significant difference in sentence repetition performance between the age groups. The subjects in these two age groups were collapsed to form one group for subsequent analyses.

A 3 x 2 mixed analysis of covariance (ANCOVA) was performed using the ANOVA II Version 1.1 computer program (Madigan & Lawrence, 1982). Speech discrimination score was used as a covariate. Table 2 shows the effects of hearing acuity on healthy elderly adults' abilities to repeat the BDAE (Goodglass & Kaplan, 1983) high and low-probability sentences.

Table 2. ANCOVA results

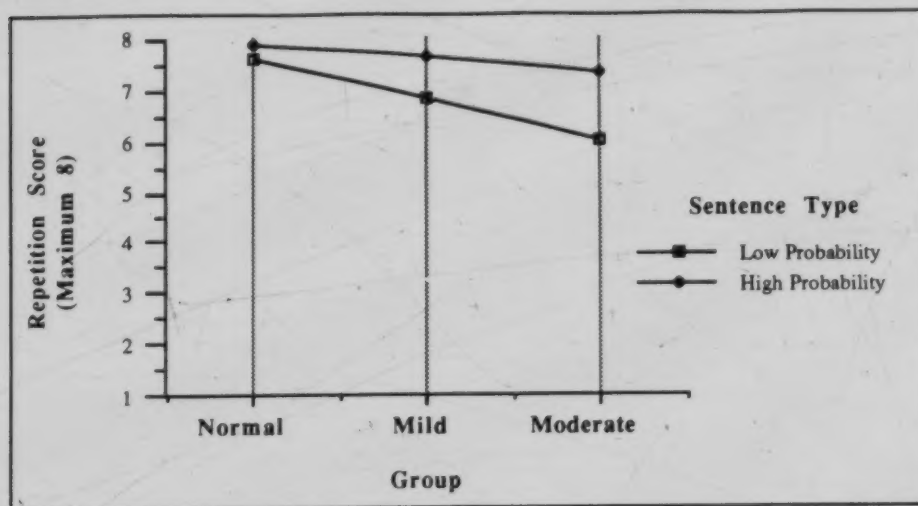
Source	Sum of Squares	df	Mean Square	F	p
Group	4.558	2	2.279	4.366	.021
Error	15.127	29	.522		
Sentence Probability	6.113	1	6.113	15.282	<.001
Group X Probability	1.802	2	.901	2.253	.121
Error	11.994	30	.400		

There was a significant main effect for the between-group variable A, level of hearing acuity ($F(2,29) = 4.366, p = .021$). Post hoc analyses using the Fisher PLSD revealed significant differences in the overall repetition score between the normal hearing and mild hearing impaired groups ($p < .05$) and normal hearing and moderate hearing impaired groups ($p < .05$). There was no significant difference between the mild and moderate hearing impaired groups in total repetition score.

There was a significant main effect for the within group variable B, sentence type ($F(1,30) = 15.282, p < .001$). Overall, participants performed considerably better on the high probability sentences than on the low probability sentences.

The interaction between group, based on hearing acuity, and sentence probability, high and low, approached significance ($F(2,30) = 2.253, p = .121$). Figure 1 illustrates the relationship between level of hearing acuity and performance on the high and low probability sentences from the BDAE (Goodglass & Kaplan, 1983) Sentence Repetition subtest.

Figure 1. Relationship between hearing acuity and sentence probability.



These data raise the question of the degree to which this subtest discriminates between changes caused by disease processes, such as aphasia or dementia and hearing impairment associated with the aging process.

Chapter V. Discussion

The results of the study will be discussed relative to the three research questions posed. The clinical implications of these results and the limitations of the study will also be considered.

Research Question #1

Hearing acuity proved to be a significant factor in healthy elderly individuals' abilities to accurately repeat the sentences from the BDAE Sentence Repetition subtest (Goodglass & Kaplan, 1983). This result suggests an alternative explanation for the findings reported by Borod et al. (1980) in their normative study of the BDAE (Goodglass & Kaplan, 1983). They found a significant negative relationship between age and repetition score for low probability sentences and a significant difference among age groups without a consistent trend favoring one end of the age spectrum in the absence of reported screening for hearing acuity. If depressed scores on these items were related to aging as hypothesized by Borod et al. (1980), then one would expect the majority of seniors to do poorly. This pattern was not observed in the present study. Rather, all seniors with normal hearing acuity obtained maximum or near maximum overall scores ($M = 15.421$, $S.D. = .838$). In comparison, elders with mild and moderate hearing impairments had significantly lower total scores ($M = 14.455$, $S.D. = 1.214$ and $M = 13.333$, $S.D. = 1.528$ respectively), although there was no significant difference between the overall scores obtained by the two hearing impaired groups.

Comparison of Young-Old (68-78 years) respondents and Old-Old (79-89 years) respondents matched on the basis of HFPTA in the better ear provides

additional support for the conclusion that the results found by Borod et al (1980) were due to hearing acuity rather than age alone. There was no significant difference found between the Young-Old and Old-Old age groups in overall sentence repetition score when groups were matched on the basis of hearing sensitivity. Thus, these results further clarify the results of Borod et al. (1980). There are many factors, such as hearing loss, which co-exist with increased age and which may affect a specific behavior under investigation. These factors must be taken into account when doing research in the field of aging.

Research Question #2

Type of sentence probability, high or low, affected the accuracy of participants' responses. Mean repetition score for high probability items ($M = 7.727$, $S.D. = .452$) was within a fraction of the maximum score whereas the mean score for low probability items ($M = 7.182$, $S.D. = .983$) was significantly lower. These results are similar to the averages reported by Borod et al. (1980) in their normative study of the BDAE (Goodglass & Kaplan, 1983). These researchers reported a mean score of 7.9 ($S.D. = .4$, range 6-8) on the high probability items and a mean score of 7.7 ($S.D. = .6$, range 5-8) on the low probability items across subjects aged 25 - 85 years. The differences in the accuracy of responses noted between the two types of sentences are not surprising because Goodglass and Kaplan (1972, 1983) purposely separated this subtest into two sets, high and low probability sentences. Sentence repetition tasks are used to differentiate between subgroups of aphasia. For example, "patients with severe anomic aphasia have an enormous overdependence on the predictability of the content, with resulting discrepancies between high- and low-probability scores" (Goodglass

& Kaplan, 1983, p. 39). On the other hand, clients with transcortical motor aphasia have a remarkable ability to repeat in the presence of otherwise limited spontaneous speech. Thus overall performance on this subtest and possible discrepancies in response patterns between the two subsets provides the speech-language pathologist with important diagnostic information when assessing adults with acquired language impairments such as aphasia. This information in association with performances on other language tasks assists the clinician to recognize and appropriately diagnose an individual's type of language impairment.

Similarly, differences in the predictability of language affect the understanding and therefore repetition ability of hearing impaired individuals who do not have aphasia. The intelligibility of a spoken message is dependent in part on the frequency of usage of constituent words and the restriction of alternatives (Rosenzweig & Postman, 1958). Frequently used words are more recognizable in the presence of noise than words with a lower frequency of usage. As well, a listener can recognize a given word more readily when it is one of two available alternatives than when it is one of ten or more. Asking a person to repeat a sentence out of context increases the choice of possible alternatives. When the information to be interpreted (or repeated) is fragmented by peripheral or central auditory problems the listener must use the lexical, semantic and contextual knowledge available and past experiences to complete the message. This may lead to uncertainty in responding. Behaviors observed during administration of the low probability items support this position. Comments such as "Is that what you said!", delays in responding, and responses made with a rising (questioning) final intonation pattern were common.

Thus, sentence probability affected the response pattern of participants as a group. Predictability of a given item can affect the way adults with aphasia and adults who have hearing impairments without aphasia respond. Similar response patterns may be observed on the surface for different underlying reasons. The speech-language pathologist must consider these factors when interpreting test results obtained from elderly clients.

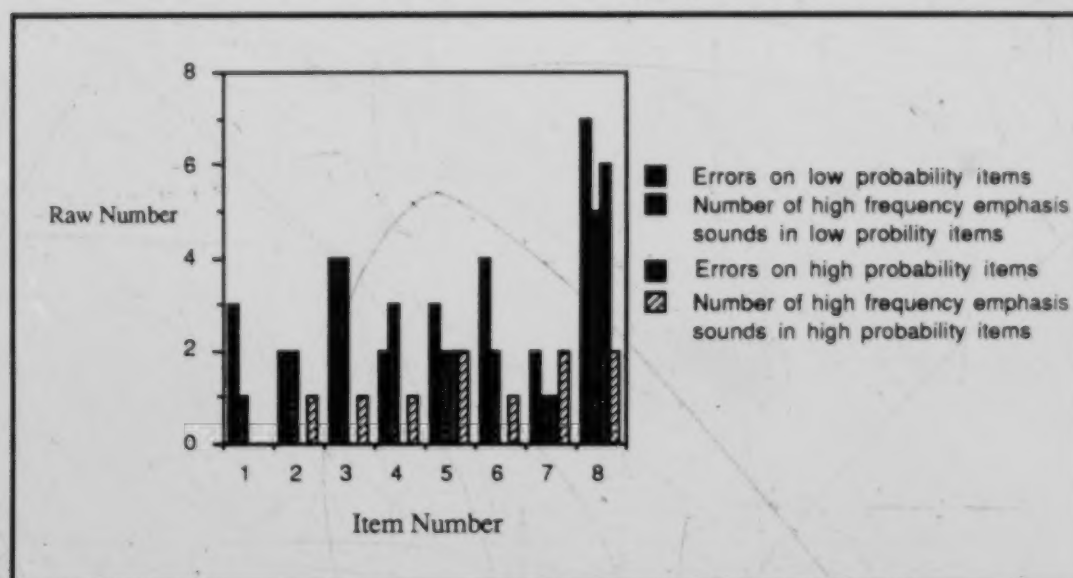
Research Question #3

The interaction between group, based on level of hearing acuity, and sentence probability type, high and low, approached statistical significance. This result suggests that elderly participants with hearing impairments may have had more difficulty accurately repeating the low probability sentences than the high probability sentences from the BDAE (Goodglass & Kaplan, 1983). Divergence of the lines in Figure 1 implies that hearing acuity and sentence probability type may interact to affect elderly people's abilities to repeat sentences. A stronger interaction effect may not have been revealed because of the small range of scores (5-8) obtained and the small number of participants with moderate hearing impairments.

This potential differential performance effect may be related to the lack of redundancy in the low probability items as discussed above, the phonemic composition of the stimuli or a combination of both factors. The low probability sentences have a greater number of high frequency peak-energy phonemes ($n=20$) than the high probability sentences ($n=10$) which may adversely affect the speech perception and repetition abilities of elderly individuals with high frequency hearing impairments (Norman, 1988, October). Analysis of the errors made by hearing impaired participants lends support to this explanation. Errors occurred in place of articulation (e.g.,

"shower" substituted for "sour"), manner of production (e.g., "fair" substituted for "fan") and voicing (e.g., "van" substituted for "fan"). These consonant phonemic errors are common among individuals with hearing impairments (Gelfand et al., 1986; Owens, Benedict & Schubert, 1972; Owens & Schubert, 1968). Specifically, people with sharply falling slopes affecting the high frequencies (500 - 4000 Hz) experienced the most difficulty perceiving /f/, /s/, /ʃ/, /tʃ/, /k/ and the initial /t/ and /θ/ (Givens & Jacobs-Condit, 1981; Owens et al, 1972; Owens & Schubert, 1968). Figure 2 illustrates the distribution of errors and high frequency peak-energy phonemes present across item number and sentence probability type. Comparisons between errors on low and high probability sentences can also be made.

Figure 2. Distribution of errors and high frequency peak-energy phonemes present by item number and probability type



There was a tendency for more errors to occur on the low probability items that contained more sounds with high-frequency emphasis's. Typically, the

substitutions for any given stimulus phoneme were limited to two or three phonemes (Owens et al., 1972). There also tended to be consistency in some erroneous responses in the present study. For example, three respondents said "fly" instead of "spy" and two individuals said "lines" for "limes". On item number eight on the high probability subset six respondents substituted the word "the" for "his". In the last case, the word "his" may violate the rules of presupposition because pronouns typically refer to subjects previously mentioned. In a single phrase this is impossible to accomplish. These changes may appear minimal but they are still considered an incorrect response according to the BDAE administration guidelines (Goodglass & Kaplan, 1983). The clinical implications of these results warrant further discussion.

Clinical Implications

The BDAE Sentence Repetition subtest (Goodglass & Kaplan, 1983) is unlikely to discriminate effectively between changes caused by disease processes such as aphasia or dementia and hearing impairment associated with the aging process. As alluded to above, this potential lack of discriminatory power may have notable clinical ramifications. The response pattern of an elderly person with a high frequency hearing impairment in the absence of aphasia may be similar to that of an individual with anomic or transcortical sensory aphasia or an individual with early stage dementia. Specifically, all of these individuals may have maximum scores on the high probability sentences and lower scores on the low probability sentences (Goodglass & Kaplan, 1983; Obler & Albert, 1981; Rosen, 1983). The surface structure of the error responses may likely be identical but for different underlying reasons. For example, one individual with a mild hearing impairment repeated the low

probability sentence "the spy fled to Greece" as "response led to grief." Similarly, these phonemic confusions could also be classified as paraphasic errors made by individuals with aphasia or dementia. Obviously, there is considerable overlap in the type of responses that may be obtained from these disparate groups. It must be remembered that such diagnoses are based on clients' performances on this subtest in comparison to performances on other language tasks. For this reason, patients are not likely to be misdiagnosed on the basis of results from this subtest alone.

Cut-off scores are used in the diagnostic process to distinguish between normal and abnormal performance levels. Such cut-off scores are usually determined by analyzing normative data and should be based on systematic criteria. Borod et al. (1980) suggested cut-off scores on 24 subtests from the BDAE (Goodglass & Kaplan, 1983) using the performances of individuals aged 25 - 85 years. They suggested cut-off scores of six for both the high and low probability sentence repetition subtests. The majority (78.6%) of participants with hearing impairments in the present study had scores which fell within these suggested limits; 21.4% of participants' scores did not fall within these limits. A cursory look at this breakdown might lead one to conclude that the hearing impaired subjects in the current study fell within acceptable limits. However, the cut off scores set by Borod et al. (1980) for 24 subtests of the BDAE (Goodglass & Kaplan, 1983) were not based on systematic criteria. Four cut-off scores were based on scores two standard deviations below the mean, 17 were based on the lowest score obtained by the normative sample and three were based on unspecified criteria. These variations imply that the cut-off scores suggested by Borod et al. (1980) were unrefined and therefore should not be interpreted as highly definitive. Future

research with neurologically intact subjects might provide information regarding the validity of these suggested cut-off scores.

It is desirable for the speech-language pathologist working with elderly patients to be cognizant of factors which may co-exist with growing older and the effects of these changes on diagnostic test performance (Dancer, 1985). Specifically, potential decline in hearing acuity is one factor which should be considered prior to making a diagnostic statement regarding a patient's language competence. One overt indicator of possible hearing impairment is an individual's request for the utterance to be repeated (Nett, Doerfler & Mathews, 1960 as cited in Giolas, 1982). More requests for repetition were made by hearing impaired participants ($n=11$) than normal hearing participants ($n=6$). However, hearing impaired individuals may also prefer to pretend they understand, guess or bluff (Nett et al., 1960 cited in Giolas, 1982). In consideration of these factors, adaptations to the standard examination procedures may need to be made. Patients may need to be told explicitly prior to the administration of the sentence repetition subtest that it is acceptable to ask to hear the item again. The instructions in the test manual presently say, "On patient's request, a single repetition of the entire test phrase is permitted without loss of credit" (Goodglass & Kaplan, 1983, page 15). The effects of these changes in administration procedures on elderly individuals' responses are not presently known. Future research comparing the effects of the standardized administration procedures with those of the suggested modified instructions on the responses of elderly individuals to the BDAE Sentence Repetition subtest would be informative.

The generalizability of the results of this study are limited to those elderly individuals who are socially and intellectually active. By virtue of the voluntary nature of this study the majority of seniors who participated were

outgoing and highly involved in community clubs and organizations. The small number of participants with moderate hearing impairments was a second limitation of this study. Differences between the two groups of participants with hearing impairments (mild and moderate) may not have been revealed because of this factor. The third limitation of the study was the ceiling effect (maximal scores) obtained by 42% (14) of the participants across both subsets. A statistically significant interaction between hearing acuity and sentence probability may not have been revealed because of the small range of scores obtained. However, conditions imposed on the task to reduce this ceiling effect (e.g., competing noise) would not have been representative of the traditional diagnostic test conditions.

Additional investigations may wish to focus on comparing the performances of individuals with and without anomic aphasia matched for hearing acuity. This comparison may reveal distinguishing patterns of responses between the two groups which would provide speech-language pathologists with useful diagnostic information. A second direction for future research may be to redevelop low probability sentences. Redevelopment of these items should consider the phonetic content of the words and sentences. Specifically, the phonetic content of the sentences should be representative of utterances used by native English speakers and balanced across sentences and probability type. Until then, the results of this study suggest that caution be exercised when interpreting the results of the BDAE Sentence Repetition subtest (Goodglass & Kaplan, 1983) with elderly individuals.

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Appendices

Appendix A. Short Portable Mental Status Questionnaire

1. What is the date today?
2. What day of the week is it?
3. What is the name of this place?
4. What is your telephone number?
 - 4A. What is your street address?
5. How old are you?
6. When were you born?
7. Who is the Prime Minister of Canada now?*
8. Who was Prime Minister just before him?*
9. Who is the President of the United States?
10. Who was the President just before him?
11. What was your mother's maiden name?
12. Subtract 3 from 20 and keep subtracting 3 from each new number, all the way down.

* denotes questions which were adapted for Canadian rather than American content.

Scoring was based on subjects' responses to the original ten questions.

Appendix B. Physical Health Status Questionnaire

1. Have you previously had a stroke? Yes No
If yes, when? _____

2. Do you have a history of cardiac disease, such as hardening of the arteries? Yes No

3. Do you have high blood pressure? Yes No
If yes, for how long? _____

4. Are you taking medications for high blood pressure? Yes No
If yes, list the name of the drug (drugs).

5. Are you taking aspirin regularly? Yes No
If yes, what is the dosage? _____

6. Are you taking any of the following medications:
 ___Antidepressives (e.g., Nardil, Pamate, Desyrel, Tofranil or Asendin),
 ___Barbituates (e.g., Seconal, Nembutal),
 ___Anorexiant (e.g., Pondimin, Ionamin), or
 ___Anticholinergics (e.g., Cogentin, Atropine).
Yes No

7. How would you rate your health at the present time?
 ___ Excellent ___ Good ___ Fair ___ Poor

Appendix C. C.I.D. W-1 Spondaic Word List

- | | |
|---------------|----------------|
| 1. greyhound | 19. baseball |
| 2. schoolboy | 20. stairway |
| 3. inkwell | 21. cowboy |
| 4. whitewash | 22. iceberg |
| 5. pancake | 23. northwest |
| 6. mousetrap | 24. railroad |
| 7. eardrum | 25. playground |
| 8. headlight | 26. airplane |
| 9. birthday | 27. woodwork |
| 10. duckpond | 28. oatmeal |
| 11. sidewalk | 29. toothbrush |
| 12. hotdog | 30. farewell |
| 13. padlock | 31. grandson |
| 14. mushroom | 32. drawbridge |
| 15. hardware | 33. doormat |
| 16. workshop | 34. hothouse |
| 17. horseshoe | 35. daybreak |
| 18. armchair | 36. sunset |

Appendix D. C.I.D. W-22 Auditory Test, List 4A (half list)

- | | |
|-----------|-----------|
| 1. all | 14. leave |
| 2. wood | 15. of |
| 3. at | 16. hang |
| 4. where | 17. save |
| 5. chin | 18. ear |
| 6. they | 19. tea |
| 7. dolls | 20. cook |
| 8. sew | 21. tin |
| 9. nuts | 22. bread |
| 10. ought | 23. why |
| 11. in | 24. arm |
| 12. net | 25. yet |
| 13. my | |

Appendix E. BDAE Sentence Repetition Subtest

Sentences were spoken by the examiner as an uninterrupted unit alternating between high and low probability sentences. Participants were asked to listen carefully and repeat exactly what they heard.

1. High Probability Sentences

- a. You know how.
- b. Down to earth.
- c. I got home from work.
- d. You should not tell her.
- e. Go ahead and do it if possible.
- f. Near the table in the dining room.
- g. They heard him speak on the radio last night.
- h. I stopped at his front door and rang the bell.

2. Low Probability Sentences

- a. The vat leaks.
- b. Limes are sour.
- c. The spy fled to Greece.
- d. Pry the tin lid off.
- e. The Chinese fan had a rare emerald.
- f. The barn swallow captured a plump worm.
- g. The lawyer's closing argument convinced him.
- h. The phantom soared across the foggy heath.

Appendix F. Consent Form

Effects of Hearing Loss on Sentence Repetition
in Healthy Elderly

Participant's Informed Consent

You are being asked to take part in a study of the effects of hearing loss on the ability to repeat sentences. These sentences are from a test used to assess the communication skills of adults. The results will help improve this tool. This study is designed to see how normal hearing loss in older adults affects the ability to repeat.

Two, 45 minute sessions will be required. Appointments will be arranged to suit you. You will be asked to provide information about your background, health status and current medications. Your hearing will be tested as part of qualifying for the study. You will be audio tape-recorded while speaking.

Please ask questions at any time. Your dignity and identity will be protected. Only I will have access to your records. These

will be coded to prevent others from knowing who you are. There should be no harmful effects from participation. You are free not to participate or to withdraw at any time.

By signing below you acknowledge that you have been adequately informed of the purpose and procedures of this project. Your signature confirms your voluntary consent to participate.

Participant's printed name

Date

Participant's signature

Investigator's signature
Jacquie Forward (435-4786)